CHAPTER 4
GROUND SURVEYS

4-1. General.

By using the overlays individually and in superposition, it is possible to design a ground sampling program. This program should take advantage of the fact that within each pattern boundary the conditions are generally uniform and that extensive sampling is not required within those boundaries. However, field investigation should be undertaken to verify that conditions in the area are as interpreted from the photos.

4-2. Ground reconnaissance.

Based on the terrain categories defined by air-photo analysis, a field study should be started. Inspection of the selected area from the ground is the only certain method of getting all necessary information for a particular site. It should include observations of soil, snow cover, vegetation, ground water, surface water, local sources of construction materials, and other pertinent information. Much valuable information regarding floods, icings, earthquakes, and landslides can often be obtained from local inhabitants. For ground reconnaissance, hand equipment, such as hand levels and augers, are generally used. For more comprehensive surveys, conventional surveying methods are employed. The extent and precision of the information to be obtained is determined by professional judgment.

a. Subsurface explorations. In the evaluation of a potential site in a permafrost area, the site location in relation to local topography and land forms is an important factor in helping to understand the character and nature of subsurface materials (see TM 5-852-8/AFM 88-19, Vol. 8). Data can be obtained by sounding rods and by percussion, rotary, and auger drilling. Adequate exploration, however, requires fairly continuous and undisturbed samples.

(1) Explorations made during the late summer or early fall may be necessary to determine the depth to the permafrost table, the location of which has an important role in most design studies and construction planning. From the standpoint of equipment mobility, the best conditions for reconnaissance and preliminary explorations in the more remote areas usually exist during the winter, while the ground surface is frozen.

(2) Probings by driving rods by hand or by use of a drill rig near the end of the thawing period are a rapid means of determining the location of the upper surface of permafrost over a large area. It is necessary to supplement probings by explorations in which soil samples are obtained for visual classification or laboratory tests. Unfrozen soils are sampled using techniques and equipment similar to those developed for the temperate zone (see App I of TM 5-818-1).

(3) Samples of frozen soils suitable for water content and classification tests can be obtained by power auger. Tungsten carbide cutting teeth on the base of augers give satisfactory service, if frozen material does not contain an excessive amount of cobbles or large boulders. It is not always possible by use of a power auger to obtain sufficiently undisturbed samples for determination of the intensity of ice segregation in soils. Relatively undisturbed samples of frozen silts, clays, and some fine, saturated sands can be obtained by drive sampling using a pipe with a tempered, sharpened cutting edge, or soil sampling tube, or by rotary drilling, using tungsten carbide saw-toothed core bits or diamond core bits.

(4) Soil that may appear to be unfrozen, especially in auger cuttings, may actually contain frozen water. If there is any doubt, the sample should be examined with great care. The soil should be warmed and carefully examined for a marked loss in strength accompanied by an apparent marked increase in water content. Such behavior definitely indicates that the sample initially contained frozen water.

(5) Borings are generally done without the use of casing except as necessary to prevent caving in the thawed portions of the hole. The test boring may be advanced from one sampling depth to the next either by churn drilling, using water for drilling fluid with additives as necessary to prevent freezing, or by rotary drilling, with a roller bit using precooled compressed air to blow the cuttings to the surface. The use of salt to depress the freezing point of the drilling fluid to a sufficiently low temperature for drilling and coring requires a considerable amount of salt, which dissolves ice in samples and often causes skin irritations. Arctic grade diesel fuel cooled by ambient air in winter or by mechanical refrigeration in summer has yielded mechanically and thermally undisturbed core samples of a wide variety of frozen soils and rocks. The use of chilled diesel fuel as the drilling fluid may be disagreeable

to operating personnel because of its odor, but it reduces the thermal disturbance of the hole wall, increases wall stability, and markedly decreases the time required for installed temperature-sensing cables to come to equilibrium. (This method is no longer used because of environmental considerations.)

(6) Samples obtained by drive sampling or cored by rotary drilling methods generally give adequate information on the nature and degree of ice segregation and permit an estimate of the magnitude of subsidence that would result upon thawing. A reliable, but slow and expensive, means of frozen ground exploration is the use of test pits, employing compressed air tools or drilling (or both) for excavation of frozen soils. Shape charges may be used to assist in excavation work. In frozen, gravelly soil, test pits may be necessary for determining the existence of segregated ice, either as buried ground ice or as pockets in frost-susceptible soils within the gravel deposit.

(7) Geophysical prospecting methods have been used to delineate permafrost bodies; however, procedures have not been fully developed to date. These methods can be used as a guide or in conjunction with exploratory drilling. Seismic and resistivity methods have proved to be most useful because the frozen interstitial water in soils and rocks causes greater changes in seismic velocity and electrical resistivity than in other geophysically measured properties. Seismic refraction techniques can be used to determine the extent and depth to the permafrost table. Theoretically, resistivity methods can also be used to measure the thickness of permafrost bodies. The reliability of geophysical prospecting methods depends to a great extent upon experience of the personnel interpreting the results.

(8) The amount and type of soil information required depend upon the character of the structure or facility that is being planned at a particular location and the uniformity of soils and permafrost conditions. Where there are nonuniform conditions, such as spotty occurrences of permafrost or various soil types, the explorations should be spaced as closely as necessary to determine the extent of these conditions. Explorations should be carried to sufficient depth to obtain information for the entire zone that is estimated to be subject to future thawing) as a result of the proposed construction. Subsurface explorations for the design of runways, taxiways, and roads should extend about 6 to 10 feet below final subgrade elevation in cut areas, and to the same depths below the existing ground surface in fill areas. A few holes should be carried deeper to determine the characteristics of the lower strata.

(9) When no cold air circulation can be provided beneath the floor, the depth of test holes beneath large heated structures, such as powerhouses or hangars, should be in excess of the theoretical depth of thaw, with a minimum depth approximately equal to the least width of the building. For building foundations where cold-air circulation can be provided, explorations should extend to a minimum of 10 feet below the theoretical depth of thaw and, in all cases, be carried to approximately 10 feet below the base of foundation support.

(10) In sporadic or discontinuous permafrost areas where a site is selected based upon the local absence of permafrost, great care should be taken to assure that small permafrost bodies are not overlooked.

b. Ground temperatures. Permafrost is defined on a temperature basis; therefore, a knowledge of the ground thermal regime is usually needed for design studies. Various possible temperature measuring methods are available, making use of probes in thermal equilibrium with the media whose temperature is to be measured. Three types of equipment commonly used are resistance thermometers, thermocouples, and thermistors, each dependent on the accuracy desired. Thermocouples encased in plastic tubes and installed in drill holes have been used successfully for geothermal studies of permafrost and studies of the stability of structures built on and in permafrost or ice. Subsurface temperatures should be recorded in the summer and fall to observe the highest range of temperatures reached in the ground. Figure 4-1 shows how ground temperatures vary in a permafrost area having a mean annual temperature of 26°F (Fairbanks, Alaska). In addition, observations essential for design are the rate and depth of thaw occurring under various terrain conditions, together with observations of ground movements because of freezing and thawing of the active zone.

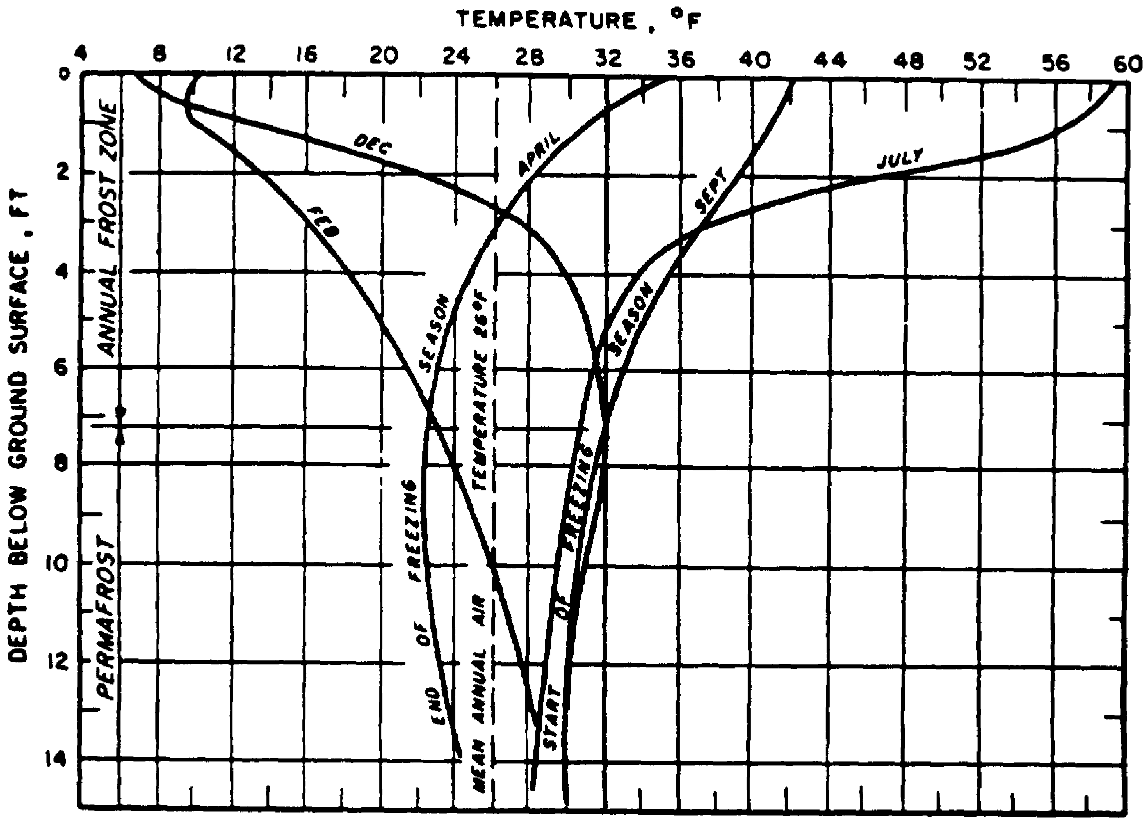

Figure 4–1. Typical ground temperatures, Fairbanks, Alaska.